

ADA 145894

SPECIAL PUBLICATION ARLCB-SP-84024

INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS — 1983

R. D. NEIFELD
TECHNICAL PUBLICATIONS AND EDITING UNIT

JULY 1984



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER LARGE CALIBER WEAPON SYSTEMS LABORATORY BENÉT WEAPONS LABORATORY WATERVLIET N.Y. 12189

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
ARLCB-SP-84024			
4. TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED	
INDEX TO BENET WEAPONS LABORATORY	(LCWSL)	Final	
TECHNICAL REPORTS - 1983			
	34.	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(8)	
R. D. Neifeld			
	*		
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT PROJECT, TASK	
US Army Armament Research & Develop	pment Center	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
Benet Weapons Laboratory, DRSMC-LC	B-TL		
Watervliet, NY 12189			
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Develor	nment Center	12. REPORT DATE	
Large Caliber Weapon Systems Labora	•	July 1984 13. NUMBER OF PAGES	
Dover, NJ 07801		117	
14. MONITORING AGENCY NAME & ADDRESS(if different	t from Controlling Office)	1S. SECURITY CLASS. (of this report)	
		UNCLASSIFIED 150. DECLASSIFICATION/DOWNGRADING	
		SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)		<u> </u>	
Approved for public release, distr	ibution unlimita		
Approved for public release; distribution unlimited.			
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different for		m Report)	
		,	
18. SUPPLEMENTARY NOTES			
10. 3071 ELMERYANI NOTES			
10 KEN WORDS (C. N.	d Ideath, by black number		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Benet Weapons Laboratory			
Technical Publications			
Bibliography			
Abstracts			
Document Control Data			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)			
This is a compilation of Benet Weapons Laboratory technical reports			
published during 1983.	Jons Laboratory	recumrear reports	
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SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)		
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ARLCB-TR-83030	,	A136	104
ARLCB-TR-83031	,	A136	184
ARLCB-TR-83032		A136	331
ARLCB-TR-83033		A136	118
ARLCB-TR-83034		A136	147
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ARLCB-MR-83036		A136	159
ARLCB-TR-83037		B078	999L
ARLCB-TR-83038		A136	156
ARLCB-MR-83039		B079	546L
ARLCB-TR-83040		A136	065
ARLCB-TR-83041		A136	133
ARLCB-TR-83042		B080	845L
ARLCB-TR-83043		A139	649
ARLCB-TR-83044		A141	447
ARLCB-TR-83045		A138	129
ARLCB-MR-83046		A138	553
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4. TITLE (and Subtitie)	TO A COMINE	5. TYPE OF REPORT & PERIOD COVERED
COMPARISON OF LAUNCH SIMULATION AND	FRACTURE	D. 1
TOUGHNESS TEST RESULTS FOR M774 DEP	LETED URANIUM	Final
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7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(*)
J. H. Underwood and M. A. Scavullo	·	
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Command		AMCMS No. 4111.16.2991.6
Benet Weapons Laboratory, DRDAR-LCB-TL		PRON No. 1A1242221A1A
Watervliet, NY 12189		PRON NO. 141242221414
11. CONTROLLING OFFICE NAME AND ADORESS		12. REPORT DATE
US Army Armament Research & Develop	ment Command	January 1983
Large Caliber Weapon Systems Labora	tory	13. NUMBER OF PAGES
Dover, NJ 07801		12
14. MONITORING AGENCY NAME & ADDRESS(If differen	t from Controlling Office)	15. SECURITY CLASS. (of this report)
		UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING
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17. OISTRIBUTION STATEMENT (of the ebetract entered in Block 20, If different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Service Simulation

Tensile Tests

Fracture

Failure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Results are presented of launch simulation tests on depleted uranium long-rod penetrators. A correlation is shown to exist between plane-strain fracture toughness, $K_{\rm IC}$, and the energy to failure measured in the simulation tests. The launch survival of the penetrators is related to $K_{\rm IC}$ and the energy to failure measured in the simulation test.

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Effects of Curing Temperature and Time on Corrosion			
Resistance, Wear Life, Adhesion and Completeness of Cure of Sandstrom Solid Film Lubricant No. 9A		Final	
		6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(*)	
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9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
Benet Weapons Laboratory, DRDAR-LC	-	AMCMS No. 3111.16.2223	
Watervliet, N.Y. 12189		DA Project.	
11. CONTROLLING OFFICE NAME AND ADDRESS		PRON NO. WG-9-RN427M11A	
US Army Armament Research and Deve	lonmont Command		
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18. SUPPLEMENTARY NOTES			
9. KEY WOROS (Continue on reverse side if necessary and	I identify by block number)		
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Corrosion resistance			
Wear life			
Accelerated tests			
0. ABSTRACT (Continue on reverse side if necessary and			
The effect of curing temperature a	nd time on a head	cured solid film lubricant	
The effect of curing temperature and time on a heat cured solid film lubricant (SFL) were investigated using accelerated corrosion and wear tests. Surface		and wear tects Sunface	
preparation and quality control inspections were also checked. Air guard critical			
were evaluated for corrosion resistance and wear life. A compromise between		fe A compromise between	
corrosion resistance and wear life must be made when selecting curing tempera		on solocting curing toward	
ture and time for heat cured SFL. Air cured SFL's showed very poor corrosion		should warm resemblera-	
resistance and wear life.			
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STRESS INTENSITY FACTORS FOR RADIAL CRACKS IN A PRE-STRESSED, THICK-WALLED CYLINDER OF STRAIN-	
HARDENING MATERIALS	Final ·
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US Army Armament Research & Development Command	AMCMS No. 611102H600011
Benet Weapons Laboratory, DRDAR-LCB-TL	DA Project No. 1L161102AH60
Watervliet, NY 12189	PRON No. 1A2250041A1A
1. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command	12. REPORT DATE
Large Caliber Weapon Systems Laboratory	February 1983
Dover, NJ 07801	13. NUMBER OF PAGES
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17. DISTRIBUTION STATEMENT (of the ebetract entered in Block 20, if different from the supplementary notes To be published in the Journal of Pressure Vess 19. KEY WORDS (Continue on reverse side if necessary and identify by block number	el Technology.
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18. SUPPLEMENTARY NOTES To be published in the Journal of Pressure Vess 19. KEY WORDS (Continue on reverse side if necessary and identify by block number Stress Intensity Pre-stressed Cylinders Strain-Hardening Materials	el Technology.
18. SUPPLEMENTARY NOTES To be published in the Journal of Pressure Vess 18. KEY WORDS (Continue on reverse eide it necessary and identity by block number Stress Intensity Pre-stressed Cylinders Strain-Hardening Materials	el Technology.
18. SUPPLEMENTARY NOTES To be published in the Journal of Pressure Vess 19. KEY WORDS (Continue on reverse eids if necessary and identify by block number Stress Intensity Pre-stressed Cylinders Strain-Hardening Materials Radial Checks	el Technology.
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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
ARLCB-TR-83004			
4. TITLE (end Subtitle) FRACTURE DAMAGE AND FAILURE OF CANNON COMPONENTS BY SERVICE LOADING		S. TYPE OF REPORT & PERIOD COVERED	
		Final	
		6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(*) J. H. Underwood	-	8. CONTRACT OR GRANT NUMBER(*)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.7280.12.1300.0 PRON NO.1A2270831A1A	
II. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory		12. REPORT DATE	
		February 1983	
		13. NUMBER OF PAGES	
Dover, NJ 07801		24	
14. MONITORING AGENCY NAME & ADDRESS(It different from Controlling Office)		15. SECURITY CLASS. (of this report)	
		UNCLASSIFIED	
		15a, DECLASSIFICATION/DOWNGRADING SCHEDULE	

16. DISTRIBUTION STATEMENT (of this Report)

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18. SUPPLEMENTARY NOTES

Presented at the 29th Sagamore U.S. Army Materials Research Conference, Lake Placid, NY, July 1982. To be published in the Proceedings of the 1982 Sagamore Conference.

19. KEY WORDS (Continue on severee elde if necessary and identify by block number)

Cannon

Fatigue Cracking

Residual Stress

Fracture Toughness

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The types of crack-related failure which occur as a result of cannon firing are reviewed. A very severe brittle fracture of an early cannon is resummarized. The failure processes typical of cannons are described, including crack initiation due primarily to high temperature exposure, fatigue crack growth due to the cyclic pressurization of firing, and final fast fracture through the wall of the cannon tube. The effects of chemical environment and residual stresses on the failure processes are discussed.

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4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
THERMO-ELASTIC-PLASTIC ANALYSIS OF A THICK-WALLED CYLINDER WITH TEMPERATURE-DEPENDENT YIELD STRESS	Final
OTHER WITH THE SECTION SECTIONS OF THE SECTION OF T	6. PERFORMING ORG. REPORT NUMBER
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9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Command	AMCMS No. 611102H600011
Benet Weapons Laboratory, DRDAR-LCB-TL	DA Project No. 1L161102AH60
Watervliet, NY 12189	PRON No. 1A2250041A1A
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
US Army Armament Research & Development Command	February 1983
Large Caliber Weapon Systems Laboratory	13. NUMBER OF PAGES
Dover, NJ 07801	18
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	15. SECURITY CLASS. (of this report)
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	15a, DECLASSIFICATION/DOWNGRADING

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abetract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at 28th Conference of Army Mathematicians, Bethesda, Maryland, 28-30 June 1982.

Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Thick-Walled Cylinder

Thermo-Elastic-Plastic

Temperature-Dependent Yield Stress

Numerical Approach

Non-isothermal

20. ABSTRACT (Cautimie em reverse side if necessary and identify by block number)

A numerical approach based on the finite-difference method and incremental solution procedure has been developed for analyzing the thermo-elastic-plastic problem of a thick-walled cylinder with temperature-dependent yield stress. The cylinder is subjected to a combination of internal pressure and temperature variation. The material is assumed to obey the von Mises' yield criterion, the associated flow theory, and the isotropic hardening rule. Some numerical results for the displacements and stresses are presented.

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A GENERALIZED RAYLEIGH-RITZ METHOD FOR STRUCTURAL DYNAMICS PROBLEMS IN CONJUNCTION WITH FINITE ELEMENTS	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
Julian J. Wu	8. CONTRACT OR GRANT NUMBER(*)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A
US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	February 1983 13. Number of pages 18
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, il different from Report)

16. SUPPLEMENTARY NOTES

To be presented at Third International Symposium on Numerical Methods for Engineering, Paris, France, 14-16 March 1983. To be published in proceedings of the symposium.

19. KEY WORDS (Continue on reverse elds if necessary and identify by block number)

Variational Method

Structural Dynamics

Finite Elements

Moving Loads

Numerical Methods

Stress Waves

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A solution formulation of generalized Rayleigh-Ritz method is described and applied to two initial and boundary value problems of stress waves and structural dynamics in conjunction with finite element discretization. Excellent numerical results have been obtained for wave equations associated with lateral and longitudinal vibrations and with strong discontinuities.

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ARLCB-TR-83007	
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
CRACK INITIATION AND PROPAGATION IN METALS IN	
LIQUID MERCURY USING FRACTURE MECHANICS	Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(e)	8. CONTRACT OR GRANT NUMBER(s)
J. A. Kapp	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Command	AMCMS No. 61110191A0011
Benet Weapons Laboratory, DRDAR-LCB-TL	DA Project No. 1L161101A9A
Watervliet, NY 12189	PRON No. 1A2231491A1A
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
US Army Armament Research & Development Command	March 1983
Large Caliber Weapon Systems Laboratory	13. NUMBER OF PAGES
Dover, NJ 07801	33
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	15. SECURITY CLASS. (of this report)
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at 1982 Fall AIME Meeting, St. Louis, MO, October 1982. Published in proceedings of the meeting.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Fracture
Fatigue
Fracture Mechanics
Liquid Metal Embrittlement

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Fracture mechanics is a useful tool in the study of sub-critical crack growth. This report presents a summary of the results of several recent fracture mechanics studies of liquid metal embrittlement. Specific topics include crack growth measurements under cyclic loading conditions in 6061-T651 alloy embrittled by liquid mercury. The effect of mean stress on fatigue crack growth in a high strength-low alloy steel in mercury is discussed. Crack (CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

growth studies under static loading conditions at various temperatures in both 6061--T651 aluminum and 70/30 alpha brass embrittled by mercury are also presented. Finally, some experiments on mercury wetted 70/30 alpha brass in Mode III loading (pure shear) are presented. The results are discussed in relation to transport mechanisms.

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. TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED
CRACK GROWTH IN MERCURY EMBRITTLED AL		Final
ALLOYS UNDER CYCLIC AND STATIC LOADING CONDITIONS		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(*)
Joseph A. Kapp		
PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL		AMCMS No. 61110191A0011
		DA Project No. 1L161101A9A PRON No. 1A2231491A1A
Watervliet, NY 12189		12. REPORT DATE
US Army Armament Research & Developme	ent Command	March 1983
Large Caliber Weapon Systems Laborate	ory	13. NUMBER OF PAGES
Dover N.I 07801		173
14. MONITORING AGENCY NAME & ADDRESS(II different I	from Controlling Office)	15. SECURITY CLASS. (of this report)
		UNCLASSIFIED
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18. SUPPLEMENTARY NOTES

This was a thesis in partial fulfillment of requirements for degree of Doctor of Philosophy in Materials Engineering at Rensselaer Polytechnic Institute, Troy, New York.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Fracture

Liquid Metal Embrittlement

Fatigue

Mercury

Fracture Mechanics

Aluminum

Adsorption

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Crack growth rates were measured on three aluminum alloys under cyclic and static loading conditions in laboratory air and in liquid mercury at about +25°C. One alloy, 6061-T651, was tested under both loading conditions at temperatures ranging from -25°C to +45°C. Fracture mechanics techniques were used.

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20. ABSTRACT (CONT'D)

Under cyclic loading conditions, no enhanced crack growth in mercury was measured until a critical stress intensity factor range (ΔK) was exceeded. When ΔK increased above the threshold value, the crack growth rate increased by as much as three orders of magnitude, when compared to the crack growth rate in air. From the appearance of the fracture surface the mechanism of embrittlement was deduced to be reduced cohesion.

Under static loading conditions, crack velocities of centimeters per second were measured in load control. Under displacement control much slower crack velocities were measured in two alloys. The decrease in crack velocity was attributed to crack blunting and large plastic zones. Static crack velocity and cyclic crack growth rate increased with decreasing temperature. This unusual temperature effect was related to the kinetics of adsorption of mercury on aluminum.

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ARLCB-TR-83009		
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
MECHANICAL PROPERTIES OF HYDROSTATICAL	LLY EXTRUDED	
URANIUM - 0.75 PERCENT TITANIUM ALLOY		Final
	190	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(=)		8. CONTRACT OR GRANT NUMBER(s)
C. J. Nolan, M. H. Kamdar, and J. H. U	Underwood	
PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Developmen	nt Command	AMCMS No. 611102H600011
Benet Weapons Laboratory, DRDAR-LCB-TI		DA Project No. 1L161102AH60
Watervliet, NY 12189		PRON No. 1A2250041A1A
1. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
US Army Armament Research & Developmen	nt Command	March 1983
Large Caliber Weapon Systems Laborator		13. NUMBER OF PAGES
Dover, NJ 07801		26
14. MONITORING AGENCY NAME & ADDRESS(It different fro	on Controlling Office)	15. SECURITY CLASS. (of thie report)
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse elde if necessary and identify by block number)

Extrusion Uranium Toughness High Pressure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study has been undertaken to improve the notch sensitivity and brittleness of uranium 0.25 wt. % titanium penetrator alloy. Hydrostatic extrusion processing has been utilized to extrude uranium alloys without cracks at room temperature up to 50 percent reduction in as received, solution treated, solution treated and aged, and homogenized conditions. The extruded billets were tested to determine the effects of percent reduction and heat treatment on the mechanical (CONT'D ON REVERSE)

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20. ABSTRACT (Cont'd)

properties, specifically strength, tensile ductility, and fracture toughness. The as received and the solution treated conditions when extruded to 50 percent reduction, showed 50 percent increase in strength. The as received alloy showed little increase in fracture toughness, while the solution treated alloy showed about 20 percent increase in fracture toughness. The results suggest that improved properties can be obtained via solution heat treatments.

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
I. REPORT NUMBER 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83010	
. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
RECENT FINDINGS AND DEVELOPMENTS IN CHROMIUM	 Final
PLATED GUN TUBES	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(e)	8. CONTRACT OR GRANT NUMBER(#)
V. P. Greco, G. D'Andrea, and J. Walden	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Command	AMCMS No. 3297.06.8243
Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	PRON No. 1A1282411A1A
II. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
US Army Armament Research & Development Command	March 1983
Large Caliber Weapon Systems Laboratory	13. NUMBER OF PAGES 22
Dover, NJ 07801 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report)
	UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRAOING SCHEDULE

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at Tri-Service Symposium on Gun Tube Wear and Erosion, Dover, NJ, 25-28 October 1982. Published in proceedings of the symposium.

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19. KEY WOROS (Continue on reverse eids if necessary and identity by block number)

Rifling Profile Chromium Plated Bores Bore Wear

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The shortcomings encountered with conventional high contraction chromium coatings in gun bores during past investigations are reviewed. Changes in the application of chromium for improving its performance during firing are proposed. Recent developments on the application of low contraction chromium with a new plating process, effects of partially plated bores on accuracy, and the effects of rifling profile on the wear of chromium coatings are discussed.

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
ARLCB-MR- 83011			
4. TITLE (and Subtitie)		S. TYPE OF REPORT & PERIOD COVERED	
Material Handling		Final	
·		6. PERFORMING ORG. REPORT NUMBER	
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7. AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(a)	
Robert J. Meinhart			
9. PERFORMING ORGANIZATION NAME AND ADDRESS		IO. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
US Army Armament Research and Deve	lopment Command	AMCMS No. 3297.06.8208	
Benet Weapons Laboratory, DRDAR-LO	B-TL	DA Project.	
Watervliet, N.Y. 12189		PRON No. M1-0-P1640-M1-1A	
11. CONTROLLING OFFICE NAME AND ADDRESS . US Army Armament Research and Deve	lopment Command	12. REPORT DATE April 1983	
Large Caliber Weapon System Labora	tory	13. NUMBER OF PAGES	
Dover, New Jersey 07801		48	
14. MONITORING AGENCY NAME & ADDRESS(II differen	t from Controlling Office)	15. SECURITY CLASS. (of this report)	
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16. DISTRIBUTION STATEMENT (of this Report)			
Approved for public release; dist	ribution unlimit	ea	
17. DISTRIBUTION STATEMENT (of the abetract entered	in Block 20, if different fro	en Report)	
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18. SUPPLEMENTARY NOTES			
Originally prepared as an MM&T project report in M		ay 1981, and submitted to	
U.S. Army Armament Materiel Readin	ess Command.		
19. KEY WORDS (Continue on reverse side if necessary as	nd identify by block number)	
Material Handling			
Overhead cranes			
Sideloading lift trucks			
Automatic guided vehicle			
20. ABSTRACT (Continue on reverse side if necessary and identity by block number) Current material handling problems encountered during the manufacturing of gun			
tubes are discussed. Solutions re			
sented. These solutions are (1)			
trucks, and (3) use an automatic guided vehicle system we trucks. Installation costs and return-on-investment are			
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ARLCB-TR-83012			
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED	
Gun Tube Extrusion		Final	
dun ruse extrusion		6. PERFORMING ORG. REPORT NUMBER	
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7. AUTHOR(#)		8. CONTRACT OR GRANT NUMBER(s)	
R. A. F <mark>arr</mark> ara			
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
US Army Armament Research and Deve		AMCMS No. 3111151100	
Benet Weapons Laboratory, DRDAR-LC Watervliet, N.Y. 12189	D-IL	DA Project.	
11. CONTROLLING OFFICE NAME AND ADDRESS		PRON No. 32-9-P5299M71 A	
. US Army Armament Research and Deve	lopment Command	April 1983	
Large Caliber Weapon Systems Labora	atory	13. NUMBER OF PAGES	
Dover, New Jersey 07801		22	
14. MONITORING AGENCY NAME & ADDRESS(If different	from Controlling Office)	15. SECURITY CLASS. (of this report)	
		UNCLASSIFIED	
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16. DISTRIBUTION STATEMENT (of this Report)			
Approved for public release; distribution unlimited			
17. DISTRIBUTION STATEMENT (of the abetract entered i	n Block 20, II dillerent from	n Report)	
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18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)			
Extrusions	, , , , , , , , , , , , , , , , , , , ,		
Gun Tubes			
Gun steel - AOD Process			
20. ABSTRACT (Continue on reverse side if necessary and	Identify by block number)		
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Hollow, two diameter, thick walled	Hollow, two diameter, thick walled cylinders were produced via the hot		
material was sup stool (4225)	extrusion process by the Curtiss-Wright Corp., Buffalo, New York The		
material was gun steel (4335V modified) produced by Electralloy Corp., Oil			
City, PA, in an argon-oxygen decarburization (AOD) vessel. The extrusions were heat treated to develop mechanical properties required for the 105mm			
M68 gun tube per the Specification MIL-S-46119. Mechanical properties			
(tension, charpy V-notch and fracture toughness specimens) were measured			
,,	5 to 5p	cormens, were measured	

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20. ABSTRACT (cont'd)

in the transverse and longitudinal directions along the length of three (3) extrusions. The macrostructure and microstructure were also examined. The mechanical properties were satisfactory; however, the charpy V-notch impact energy was marginal. The dimensions, straightness, and wall thickness variations were consistent and met the requirements. Although more material had to be removed, compared to conventional forgings, the total time for machining an extrusion would not be more than for conventional forgings because they are easier to straighten and set up than the normal tapered forgings.

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1. REPORT NUMBER	. REPORT NUMBER 2. GOVT ACCESSION NO.			
ARLCB-SP-83013				
4. TITLE (and Subtitie)		5. TYPE OF REPORT & PERIOD COVERED		
INDEX TO BENET WEAPONS LABORATORY	(LCWSL)	Final		
TECHNICAL REPORTS - 1982		6. PERFORMING ORG. REPORT NUMBER		
7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(s)		
R. D. Neifeld				
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS		
U.S. Army Armament Research & Devel	-			
Benet Weapons Laboratory, DRDAR-LCI Watervliet, NY 12189	5-1L			
11. CONTROLLING OFFICE NAME AND ADDRESS	******	12. REPORT DATE		
U.S. Army Armament Research & Deve	-	April 1983		
Large Caliber Weapon Systems Labora	atory	13. NUMBER OF PAGES		
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		15e. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report)	16. DISTRIBUTION STATEMENT (of this Report)			
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17. DISTRIBUTION STATEMENT (of the abstract entered	in Block 20, if different fro	m Report)		
18. SUPPLEMENTARY NOTES				
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)				
Benet Weapons Laboratory				
Technical Publications Bibliography				
Abstracts				
Document Control Data				
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This is a compilation of Benet Weapons Laboratory technical reports				
published during 1982.				
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. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
ARLCB-TR-83014			
. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED	
Recycling of Scrap Gun Tubes b	y Rotary Forging	Final	
	•	6. PERFORMING ORG. REPORT NUMBER	
AUTHOR(*)		8. CONTRACT OR GRANT NUMBER(*)	
Charles Calderone			
PERFORMING ORGANIZATION NAME AND ADDR US Army Armament Research and D	ESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
Benet Weapons Laboratory, DRDAR	R-LCB-TL	AMCMS No. 3297.06.7727	
Watervliet, N.Y. 12189		PRON No. M1-9-P1589-M1-1A	
1. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE	
US Army Armament Research and D		April 1983	
Large Caliber Weapon Systems La	boratory	13. NUMBER OF PAGES	
Dover, New Jersey 07801		33	
14. MONITORING AGENCY NAME & ADDRESS(If diff	erent irom Controlling Office)	15. SECURITY CLASS. (of thie report)	
2		UNCLASSIFIED	
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A. DISTRIBUTION STATEMENT (of this Report)		L	

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17. DISTRIBUTION STATEMENT (of the ebelract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T project to the U.S. Army Armament Materiel Readiness Command in September 1981.

19. KEY WOROS (Continue on reverse elde if necessary and identify by block number)
Rotary Forge Intermediate Preform

Recycling

Vacuum Degassing

Scrap tubes

Vacuum Deoxidizing (VDox)

Fired-out

Electroslag Refining (ESR)

Preform

20. ABSTRACT (Continue on reverse eide if necessary and identify by block number)

Recycling of gun tubes has been a two-year MM&T effort by the Advanced Engineering Section of Benet Weapons Lab at Watervliet Arsenal. The basic approach involves rotary forging of scrap (fired-out, mismachined, obsolete, etc.) tubes directly into a new tube forging of smaller size without any intermediate melting operation.

The preliminary phase or first year's effort of this project determined the quantities of scrap tubes available for recycling and future tube production

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requirements. This phase was then followed by processing a sample quantity of scrap tubes from the field. Since tubes with the largest volume of material showed the most potential for recycling, emphasis was placed on locating larger tubes; namely, 8" M2A2 and 175mm M113 gun tubes. Other tube models, such as the 155mm M185, were also included in the study. The samples of selected tubes were then inspected for the extent of damage. Based on the firing damage, a standard machining procedure was established to prepare a tube for recycling.

A computer program was then developed which, based on tube dimensions, generates an optimum mix of new tubes that can be produced giving the required preform dimensions. Based on this computer program, scrap tubes were cut and recycled through the Rotary Forge.

The overall results proved that scrap tubes can be made into acceptable forgings that meet the dimensional drawing requirements. The follow-up heat treatment and mechanical property testing resulted in less than half of the tubes meeting the required mechanical properties. However, in analyzing these results, the older scrap tubes produced by air melting practices, resulted in very few with acceptable mechanical properties. The scrap tubes of a more recent vintage originally, produced from newer melting practices such as, vacuum degassing, vacuum deoxidizing, and electroslag refining resulted in nearly 100% with acceptable mechanical properties.

The recycling program will result in substantial cost savings when applied to scrap tubes originally produced from the newer melting practices.

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REPORT DOCUMENTATION	PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83015		
4. TITLE (and Subtitie)		5. TYPE OF REPORT & PERIOD COVERED
Rotary Forging of the M483Al Projectile Body		Final
7763666776 2003		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(a)
Leonard Liuzzi		
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Dev Benet Weapons Laboratory, DRDAR-L Watervliet, N.Y. 12189	.CB-IL	AMCMS No. 49500566810 DA Project. PRON No. 81826748GGM7
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
US Army Armament Research and Devel		April 1983
Large Caliber Weapon;Systems Laboratory Dover, New Jersey 07801		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if differen	t from Controlling Office)	42 15. SECURITY CLASS. (of this report)
		UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)		
Distribution limited to U.S. Gove evaluation; April 1983. Other req Cdr., ARRADCOM,ATTN:Benet weapons 12189.	uests for this d	ocument must be referred to
17. DISTRIBUTION STATEMENT (of the abetract entered	in Block 20, if different from	m Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Rotary Forge Projectile Body Forging Forging, Steel

20. ABSTRACT (Continue on reverse elde it necessary and identify by block number)

The rotary forge process has been used for the production of cannon tube forgings since 1978. To form the bore, a stub (partial length) mandrel is used. To form the internal diameter of a closed cylinder, a full length mandrel must be employed. This presents some questions regarding the viability of the process.

Continued on back

20. ABSTRACT:

As part of a project to maximize productivity in the production of 155mm M483Al projectile bodies, the rotary forge process was evaluated. Since the projectile body was to be forged as a closed cylinder, a full length mandrel had to be employed. Trial forgings were produced on a GFM machine in Steyr, Austria, on preforms produced by Chamberlain Manufacturing Corp. Several types of preforms were evaluated, including as-forged and machined. It was determined that the projectile body can be rotary forged with a reduction in weight compared to standard forging techniques. However, because of the commitment to equipment already made at the several ammunition plants, a significant economic benefit can be realized only under full mobilization production conditions.

REPORT DOCUMENTATION R	PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83016		
4. TITLE (and Subtitie) EVALUATION OF SUPERCONDUCTING AUGMEN RAIL GUN SYSTEM	S. TYPE OF REPORT & PERIOD COVERED	
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) C. G. Homan and W. Scholz		8. CONTRACT OR GRANT NUMBER(#)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Developm Benet Weapons Laboratory, DRDAR-LCB- Watervliet, NY 12189		AMCMS No. 6111.02.H600.011 Pron No. 1A325B541A1A
US Army Armament Research & Developm		June 1983
Large Caliber Weapon Systems Laboratory Dover, NJ 07801		13. NUMBER OF PAGES 24
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the obstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at 4th International Pulsed Power Conference, Albuquerque, NM. June 1983. Published in proceedings of the Second Symposium on Electromagnetic Launch Technology

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Launch Efficiency

Normally Conducting Augmentation

Constant Rail Current

Superconducting Augmentation

Variable Rail Current

System Comparison

20. ABSTRACT (Continue on reverse state if necessary and identify by block number)
The simple rail gun and rail guns with normally conducting and superconducting augmentation are discussed using an energy approach. Ideal launch efficiencies neglecting Joule losses and assuming constant rail current during the launch are shown to be 50 percent for normally conducting systems, and up to 100 percent for systems with superconducting augmentation. Energy requirements of an actual system are compared with expected values for a system with superconducting augmentation. The situation of variable rail currents has also been discussed.

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1. REPORT NUMBER 2. GOVT AC	ESSION NO. 3. RECIPIENT'S CATALOG NUMBER
ARLCB-MR-83017	
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
Improved Inspection Techniques for Ingots Preforms for Rotary Forging	and Final
	6. PERFORMING ORG. REPORT NUMBER
7. William Sullivan Vito Colangelo	8. CONTRACT OR GRANT NUMBER(*)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK
US Army Armament Research and Development	Command AMCMS No. 3297.06.8048
Benet Weapons Laboratory, DRDAR-LCB-TL	DA Project.
Watervliet, N.Y. 12189	PRON No. MI-8-P1890-MI-1A
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
US Army Armament Research and Development Large Caliber Weapon Systems Laboratory	Command May 1983
Dover, New Jersey 07801	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(tf different from Control	ting Ottice) 15. SECURITY CLASS. (of this report)
	UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
18. DISTRIBUTION STATEMENT (of this Report)	
18. DISTRIBUTION STATEMENT (of the Report)	
Approved for public release; distribution	unlimited
17. DISTRIBUTION STATEMENT (of the abetract entered in Block 20, I	ditierent from Report)
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18. SUPPLEMENTARY NOTES Originally submitted as an MM&T project to	the U.S. Army Armament Material
Readiness Command.	
19. KEY WORDS (Continue on reverse side if necessary and identify by	tock number)
Ultrasonic Inspection ESR Ingot Inspection	
Non-Destructive Testing	
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20. ABSTRACT (Continue on reverse side if necessary and identify by be This report outlines the work conducted in inspection facility for the inspection of forging. The details of the system included rawings are available as a Technical Date Watervliet, N. Y.	developing a semi-automatic production ngots and preforms prior to hot ng descriptions, procedures and
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REPORT NUMBER 2. GOVT ACCESSION NO. ARLCB-MR-83018	
GROUP TECHNOLOGY OF WEAPON SYSTEMS	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
J. Cocco	8. CONTRACT OR GRANT NUMBER(*)
U.S. Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	AMCMS No. 3297.06.7724 PRON No. M1-9-P1594-M1-1A
U.S. Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE May 1983 13. NUMBER OF PAGES 11
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	UNCLASSIFIED 15. DECLASSIFICATION/DOWNGRADING SCHEDULE

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T project to the U.S. Army Armament Materiel Readiness Command in September 1982.

19. KEY WORDS (Continue on reverse side if necessary end identify by block number)

Group Technology

MICLASS

Part Families

Rotational Parts

Manufacturing Cells

Standard Process Planning

Part Coding

Automation

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

Group technology provides a method of classifying manufactured parts such that pertinent information concerning the parts is retained in the assigned code number. This study investigated the effect a group technology system would have upon the manufacturing of parts used in armaments. Conclusions drawn indicate a potential productivity improvement could be realized if group technology were employed.

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ARLCB-TR-83019		
4. TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED
ENGRAVING OF ROTATING BANDS - A MOD	IFICATION OF	
METAL-FLOW PATTERN		Final
		6. PERFORMING ORG. REPORT NUMBER
7. AuTHOR(a)		8. CONTRACT OR GRANT NUMBER(*)
Dr. Boaz Avitzur		
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Command		AMCMS No. 6111.02.H600.011
Benet Weapons Laboratory, DRDAR-LCB Watervliet, NY 12189	-TL	PRON No. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
US Army Armament Research & Develop	ment Command	June 1983
Large Caliber Weapon Systems Labora		13. NUMBER OF PAGES
Dover, NJ 07801		30
14. MONITORING AGENCY NAME & ADDRESS(II differen	nt from Controlling Office)	IS. SECURITY CLASS. (of this report)
		UNCLASSIFIED
		ISA, DECLASSIFICATION/DOWNGRADING SCHEDULE

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, If different from Report)

18. SUPPLEMENTARY NOTES

Presented at Tri-Service Symposium on Gun Tube Wear and Erosion, Dover, NJ, 25-28 October 1982.
Published in proceedings of the symposium.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Rotating Bands Engraving Commencement-of-Rifling

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

An evaluation of the commencement-of-rifling (C.O.R.) geometry suggests that the mode of deformation of the rotating band by the rifling is inefficient. Observation of rotating bands of fired and retrieved projectiles confirms the above evaluation. Engravers, simulating the conventional design of C.O.R. as well as the proposed modification, were fabricated. Slugs of rotating band material were engraved with the simulated engravers. Metallographic data on (CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

the laboratory engraved slugs were compared with those of retrieved projectiles; results from the two simulating designs were also compared. Similarities were found between retrieved bands and simulated conventional design, while the simulated modification resulted in change in metal-flow pattern close to the intended one. Reduced engraving forces were observed as predicted and can be explained by reduced deformation forces when the modified design of C.O.R. is being simulated. It is suggested that reduced deformation forces will reduce wear at the commencement-of-rifling.

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83020		
4. TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED
RESULTS OF THE 105MM M68 GUN TUB WEAR SURVEY 1981-82	E	Final-1981-82
WEAR SURVEY 1981-82		6. PERFORMING ORG. REPORT NUMBER
		8. CONTRACT OR GRANT NUMBER(*)
7- AUTHOR(s)		
B. J. ROWEKAMP		
		TASK
9. PERFORMING ORGANIZATION NAME AND ADORESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Benet Weapons Laboratory Watervliet Arsenal, Watervliet,	NY 12189	AMCMS No. 41111629780
DRDAR-LCB-DP	11 12105	DA Project. PRON No. M18GG063M11A
11. CONTROLLING OFFICE NAME AND ADORESS	<u>, , , , , , , , , , , , , , , , , , , </u>	12. REPORT DATE
US Army Armament Research and Deve	lopment Command	May 1983
Large Caliber Weapon Systems Labor Dover, New Jersey 07801	atory	13. NUMBER OF PAGES 59
14. MONITORING AGENCY NAME & ADDRESS(If differen	t from Controlling Office)	15. SECURITY CLASS. (of this report)
		Unclassified
		15a. OECLASSIFICATION DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)		
Distribution limited to U.S. Gov April 1983). Other requests for ARRADCOM, ATTN: Benet Weapons La	ust be referred to Commander,	
17. OISTRIBUTION STATEMENT (of the abatract entered	in Block 20, if different iro	om Report)
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IS. SUPPLEMENTARY NOTES		
is. Supplement and the last		
19. KEY WOROS (Continue on reverse side if necessary as	nd Identify by block number	•)
Primary Wear	Stargage	
Secondary Wear	Pullover Gage	
Primary Land Wear	Borescope	
Secondary Groove Wear		
Secondary Land Wear 20. ABSTRACT (Continue on reverse side II recessary on	ed Identify by block number)	
This presents the background, pr 105mm M68 Gun Tube (M60/M-1 Tank recorded tube wear on a sample b	rocedures, result () Wear Survey. Dasis of gun tube	s and conclusions of the The survey measured and
in the U.S., Germany and the Nat	tional Guard.	

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 2. GOVT ACCESSION NO. ARLCB-TR-83021	3. RECIPIENT'S CATALOG NUMBER
LARGE CALIBER POWDER CHAMBER BORING	s. Type of REPORT & PERIOD COVERED Final Technical Report Jan 80 - Sep 82 6. PERFORMING ORG. REPORT NUMBER
7. Autнок(e) Alex Wakulenko	8. CONTRACT OR GRANT NUMBER(*)
US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	AMCMS No. 3297.06.8106 PRON No. MI-0-P1639-MI-1A
US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801 14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	12. REPORT DATE May 1983 13. NUMBER OF PAGES 65 1s. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

Distribution limited to US Government Agencies only because of proprietary information; May 1983. Other requests for this document must be referred to Commander, ARRADCOM, ATTN: Benet Weapons Laboratory, DRDAR-LCB-SE, Watervliet Arsenal, Watervliet, NY 12189.

17. DISTRIBUTION STATEMENT (of the abetract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T project to the U.S. Army Armament Materiel Readiness Command in September 1982.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Large Caliber Powder Chamber Boring Balanced Tool Boring Contour Boring

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is the first phase of a project established to improve the current powder chamber contour boring operation to eliminate a semifinish grinding requirement. The first part consisted of the engineering and design efforts conducted to arrive at the optimum cutting system.

The results are a design of a balanced cutting force Boring Bar System employing two diametrically opposed cutting tools which are independently (CONT'D ON REVERSE)

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20. ABSTRACT (CONT'D)

positioned by two internal cam and slide assemblies. Also, a specification was prepared to purchase a Precision Positioning System which will provide programmable tool positioning and control to the Boring Bar System. Together these two systems will form a Computer Numerical Control (CNC) operated contour boring unit which can produce powder chambers in 155mm cannon tubes.

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 2. GOVT ACCESSIO	N NO. 3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83022	
4. TITLE (and Subtitie)	S. TYPE OF REPORT & PERIOD COVERED
METALLOGRAPHIC STUDIES OF EROSION AND THERMO-	Final
CHEMICAL CRACKING OF CANNON TUBES	6. PERFORMING ORG. REPORT NUMBER
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*)	8. CONTRACT OR GRANT NUMBER(a)
R. M. Fisher*, A. Szirmae*, and M. H. Kamdar	
*Cont'd on Reverse	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
JS Army Armament Research & Development Command	
Benet Weapons Laboratory, DRDAR-LCB-TL	AMCMS No.691000H840021
Vatervliet, NY 12189	PRON No.182279141A1A
1. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
JS Army Armament Research & Development Command	May 1983
Large Caliber Weapon Systems Laboratory	19. NUMBER OF PAGES
OVET, NJ 07801 14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Of	16 fice) 15. SECURITY CLASS. (of this report)
44. MONITORING AGENCY NAME & ADDRESSIT different from Controlling Of	is. Security CLASS. (or this report)
	Unclassified
	15a. DECLASSIFICATION/DOWNGRADING
	SCHEDULE
6. DISTRIBUTION STATEMENT (of this Report)	
Approved for public release; distribution unl	limited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at the Tri-Service Gun Tube Wear and Erosion Symposium, ARRADCOM, Dover, NJ, October 1982 and published in the Proceedings.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Guns

Erosion

Thermo-Chemical

Cracking

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

The characteristic erosion features of fired cannons and the closely related surface alterations on laboratory simulation samples have been examined with a variety of electron optical and other analytical techniques. The results suggest that the heat-checking pattern is caused by the large differential thermal contraction between surface austenite and subsurface tempered martensite, the deep longitudinal cracks result from liquid-solid metal (CONT'D ON REVERSE)

DD 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

7. AUTHOR(S)

R. M. Fisher and A. Szirmae U.S. Steel Corporation Research Laboratory Monroeville, PA 15146

20. ABSTRACT

embrittlement primarily by copper, and the subsurface microstructural alterations are a consequence of intense carburization by the explosion gases. The observations could provide the basis for thermomechanical modeling of the erosion and cracking of cannon tubes.

SECURITY CLASSIFICATION OF THIS PAGE (When Date Entered)				
REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM			
1. REPORT NUMBER ARLCB-TR-83023 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER			
4. TITLE (and Subtitio) ELASTIC—PLASTIC ANALYSIS OF ANNULAR PLATE PROBLEMS USING NASTRAN	5. TYPE OF REPORT & PERIOD COVERED FINAL 6. PERFORMING ORG. REPORT NUMBER			
7. AUTHOR(s) P. C. T. Chen	8. CONTRACT OR GRANT NUMBER(a)			
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	AMCMS No6111.02.H600.011 PRON No.1A325B541A1A			
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801 14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	12. REPORT DATE May 1983 13. NUMBER OF PAGES 18 15. SECURITY CLASS. (of this report) UNCLASSIFIED			
16. DISTRIBUTION STATEMENT (of this Report)	150. DECLASSIFICATION/DOWNGRADING SCHEDULE			

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abetract entered in Block 20, il different from Report)

18. SUPPLEMENTARY NOTES

Presented at the 11th NASTRAN Users' Colloquium, San Francisco, CA, 5-6 May 1982.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

NASTRAN Program Finite Elements Annular Plate Plastic Deformation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The plate elements of the NASTRAN code are used to analyze two annular plate problems loaded beyond the elastic limit. The first problem is an elastic-plastic annular plate loaded externally by two concentrated forces. The second problem is stressed radially by uniform internal pressure for which an exact analytical solution is available. A comparison of the two approaches together with an assessment of the NASTRAN code is given.

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REPORT DOCUMENTATION	READ INSTRUCTIONS BEFORE COMPLETING FORM				
I. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER			
ARLCB-TR-83024					
4. TITLE (and Subtitie)	S. TYPE OF REPORT & PERIOD COVERED				
A FUNCTIONAL STRESS INTENSITY APPRO MULTIPLY CRACKED, PARTIALLY AUTOFRE	Final				
CYLINDERS	6. PERFORMING ORG. REPORT NUMBER				
7. AUTHOR(*)	8. CONTRACT OR GRANT NUMBER(a)				
S. L. Pu					
9. PERFORMING ORGANIZATION NAME AND ADDRESS	\$	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS			
US Army Armament Research & Develop	AMCMS No. 611102H600011				
Benet Weapons Laboratory, DRDAR-LCB	DA Project No. 1L161102AH60				
Watervliet, NY 12189	PRON No. 1A2250041A1A				
1. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE				
US Army Armament Research & Develop	June 1983				
Large Caliber Weapon Systems Labora	13. NUMBER OF PAGES 28				
Dover, NJ 07801	15. SECURITY CLASS. (of this report)				
14. MONITORING AGENCY NAME & ADDRESS(II different from Controlling Office)					
		UNCLASSIFIED			
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE			

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at 28th Conference of Army Mathematicians, Bethesda, Maryland, 28-30 June 1982.

Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Multiple Cracks Thick-Wall Cylinder Stress Intensity Factors Residual Stresses Finite Elements Weight Functions

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The functional stress intensity approach is presented for a partially autofrettaged, thick-walled cylinder. This approach is a combination of a series
of methods developed for the computation of stress intensity factors for
multiple-radial cracks emanating from the inner or the outer surface of a
hollow cylinder. The numerical method is mainly based on the finite element
method using 12-node quadrilateral, isoparametric elements with singular
(CONT'D ON REVERSE)

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20. ABSTRACT (Cont'd)

elements around a crack tip. The difficulty due to the presence of initial stresses in the finite element method is obviated by the method of thermal simulation which replaces the residual stresses existing in an autofrettaged cylinder by an active thermal load. The weight function method is incorporated to reduce the repeated computations of stress intensity factors of the same geometrical configuration subjected to various external loads and residual stresses. The functional stress intensity factor is introduced to overcome the difficulty in seeking the weight function itself.

Numerical results of functional stress intensity factors are given for multiple cracks radiating from the bore or from the outer surface of a cylinder having an external diameter twice that of an internal diameter. A linear superposition of these results gives the resultant stress intensity factor of a cracked geometry subjected to combined external loads and initial stresses. It is highly possible to extend the method outlined in this report for elastic-perfectly plastic material to strain-hardening materials.

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
I. REPORT NUMBER 2. GOVT ACCESSION NO. ARLCB-TR-83025	3. RECIPIENT'S CATALOG NUMBER
EROSION CONTROL IN CHROMIUM PLATED CANNON TUBES	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) R. S. Montgomery and F. K. Sautter	8. CONTRACT OR GRANT NUMBER(e)
D. PERFORMING ORGANIZATION NAME AND ADDRESS JS Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A
1. CONTROLLING OFFICE NAME AND ADDRESS JS Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	June 1983 13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWN GRADING SCHEDULE

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17. DISTRIBUTION STATEMENT (of the abetract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse elds if necessary and identify by block number) Erosion Spalling Plastic Rotating Bands Traction Stresses Duplex Coatings Chromium Plating Nitriding Cannon Bores Dispersion Hardening Engraving Stresses Sandblasting Stresses Residual Stresses Pre-engraved Rotating Bands Autofrettaging

20. ABSTMACT (Continue on reverse state of messesses and identity by block number)
The chief cause of erosion in chromium plated cannon bores is mechanical stresses. Chromium is chemically inert to the propellant gases and does not melt at the bore temperature. Erosion can be controlled in chromium plated cannon tubes by lowering the stresses on the plate, by decreasing the effect of the stresses, or by both of these used in conjunction.

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83026		FE 61
4. TITLE (and Subtitie)		5. TYPE OF REPORT & PERIOD COVERED
SUPERCONDUCTIVITY IN HYDROGEN-CHARG MIXED PALLADIUM COPPER ALLOY	ED ION-BEAM	
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(s)
W. Scholz*, A. Leiberich*, W. J. St C. G. Homan	andish*, and	
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Develop		AMCMS NO.6111.02.H600.011
Benet Weapons Laboratory, DRDAR-LCB	-TL	D.A.Proj.1L161102AH60
Watervliet, NY 12189		PRON NO 1A2250041A1A
11. CONTROLLING OFFICE NAME AND ADDRESS		
US Army Armament Research & Develop Large Caliber Weapon Systems Labora		June 1983 13. NUMBER OF PAGES 13
Dover, NJ 07801	nt from Controlling Office)	15. SECURITY CLASS. (of this report)
		UNCLASSIFIED
	,	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of thie Report)		
Approved for public release; di	stribution unlimi	ited
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17. DISTRIBUTION STATEMENT (of the abstract entered	in Biock 20, if different fro	om Report)
18. SUPPLEMENTARY NOTES		
Presented at the International	Conference on Tor	Beam Modification of
Materials, Grenoble, France, 6-		
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19. KEY WORDS (Continue on reverse side if necessary a	nd identify by block number)
Superconductivity		
Palladium Copper Hydride		
Ion-Beam Mixed Alloy		
Transition Temperature		
20. ABSTRACT (Continue on reverse side if necessary as	ad identify by block number	
Superconducting Pd _x Cu _{1-x} (H) has bee		
temperature electrolysis. A multi-		
layers of Cu and Pd, sputter-deposi		
with 125 KeV Xe+ ions. Analysis by	Rutherford backs	scattering (RBS) showed the
formation of a Pd 6Cu 4 alloy regio	n approximately	38 µg/cm ² thick. After
electrolytic charging with H at dry	ice temperature	, superconductivity was
		ONT'D ON REVERSE)

7. AUTHOR(S) (CONT'D)

*W. Scholz, A. Leiberich, and W. J. Standish State University of New York at Albany Albany, NY 12222

20. ABSTRACT (CONT'D)

observed, with a transition temperature, T_C, of 11.4 K in the alloy region. The effects of increased currents and changes in the H distribution due to annealing between 77 K and 85°C on the transition curves have been investigated. Transition curves produced in this fashion are broad with an onset of the superconducting transition as high as 14 K. The sample remains partially superconducting even after overnight anneal at room temperature. Electrolysis at room temperature also produces superconducting transitions with onsets as high as 17 K.

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 2. GOVT ACCESSION NO	. 3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83027 4. TITLE (end Subtitio) FATIGUE BEHAVIOR IN MUZZLE REGION OF CERTAIN 105 MM M137A1 HOWITZER TUBES	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) Bruce B. Brown	8. CONTRACT OR GRANT NUMBER(a)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 738017.100Q1 PRON No. 1A2265691A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command	June 1983
Large Caliber Weapon Systems Laboratory Dover, NJ 07801	13. NUMBER OF PAGES 46
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	UNCLASSIFIED 15. DECLASSIFICATION/DOWNGRADING SCHEDULE

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17. DISTRIBUTION STATEMENT (of the abetraci entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse elde if necessary and identify by block number)

Howitzer

Residual Stress

105 mm M137A1

Fracture Toughness

Muzzle

Safe Service Life

Fatigue

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Six 105 mm M137Al howitzers were subjected to hydraulic fatigue testing and analysis to better define a recently discovered muzzle end crack problem. Four of the specimens contained abnormal initial cracking and displayed short fatigue lives. Two specimens with far fewer rounds fired did not have this abnormal initial cracking and gave greater laboratory fatigue lives. Analysis showed low residual stress at the failure region of all six samples. Safe life reliability results are shown for several analytical approaches.

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
I. REPORT NUMBER ARLCB-TR-83028 (Rev.)	3. RECIPIENT'S CATALOG NUMBER
A CLOSURE-PACKING SYSTEM TO MINIMIZE END EFFECTS ON PRESSURIZED CYLINDERS	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) Bruce B. Brown	8. CONTRACT OR GRANT NUMBER(*)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	AMCMS No. 69100R.40800.21 PRON No. 1A325F161A1A
US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	June 1983 13. Number of pages 21
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	UNCLASSIFIED 15. DECLASSIFICATION/DOWNGRADING SCHEDULE

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17. DISTRIBUTION STATEMENT (of the abetract antered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This report is reissued to include Figure 7, which was inadvertently omitted.

19. KEY WORDS (Continue on reveree side if necessary and identify by block number)

Closure-Packing System

Hydraulic

Seal

Fatigue Test

Cylinder

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Conventional closure-packing systems used to seal pressure vessel cylinders cause diminished stress at the ends of the cylinders. This end effect is the result of the pressure seal being placed a distance in from the cylinder end. While this is beneficial in most pressure vessel designs, it is inappropriate for use in the testing of cylinders when service conditions place full internal pressure to the cylinder ends and these cylinder ends contain potential fatigue (CONT'D ON REVERSE)

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20. ABSTR	ACT (CONT'D)			
critical f	eatures. A closur he end effect. Th	e-packing system he end effects have	as been developed been measured and	to greatly l the system
successful	ly used in a high	pressure hydraulic	fatigue test.	
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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 2. GOVT ACCESSION N ARLCB-TR-83029	O. 3. RECIPIENT'S CATALOG NUMBER
STUDIES OF REFRACTORY METAL COATINGS FOR ADVANCED GUN BARRELS	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
L. Ahmad, J. Barranco, P. Aalto, and J. Cox	8. CONTRACT OR GRANT NUMBER(a)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6126.03.H181.211 PRON No. 1A0216131A1A
US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE July 1983 13. NUMBER OF PAGES 70
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office	UNCLASSIFIED 15. DECLASSIFICATION/DOWNGRADING SCHEDULE
Distribution limited to US Government Agencies on evaluation; July 1983. Other requests for this decommander, US Army Armament Research and Development Weapons Laboratory, DRSMC-LCB-RP, Watervliet, NY	ocument must be referred to ent Center, ATTN: Benet

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

16. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse elde if necessary and identify by block number)

Erosion Gun Barrels

Electrodeposition 20 mm Gun

105 mm Gun Tantalum Refractory Metals Flinak

Liners Pyrotool V

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the results of a study of the application of tantalum coatings in gun barrels and its performance as a protective measure for erosion control. The feasibility of plating liners both for 20 mm M24Al barrels and 105 mm M68 with 15 mil thick tantalum by electrodeposition from fused eutectic mixture of fluorides of K, Na, and Li has been demonstrated. On test firing tantalum coating in M24Al barrels out performed the conventional 5 mil thick (CONT'D ON REVERSE)

Gun Steel

20. ABSTRACT (Cont'd)

HC chromium coating. The coating, however, showed some swaging. Codeposition of one to five percent chromium was found to predictably increase the hardness of tantalum coating. The formation of β -tantalum phase was discovered during coating 105 mm liners. It is a hard brittle phase. Preliminary test firing of 105 mm M68 with tantalum coated liners have also shown encouraging results.

REPORT DOCUMENTATION F	PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
· ARLCB-TR- 83030		
4. TITLE (end Subtitle) BEHAVIOR OF PRESSURIZED CYLINDERS WI INTERNAL CRACKS	TH MULTIPLE	S. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. Author(*) J. F. Throop and R. Fujczak		8. CONTRACT OR GRANT NUMBER(*)
D. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Developm Benet Weapons Laboratory, DRSMC-LCB Watervliet, NY 12189		AMCMS No.6111.02.H60011 PRON: 1A2250041A1A
US Army Armament Research & Developm Large Caliber Weapon Systems Laborat Dover, NJ 07801 14. MONITORING AGENCY NAME & ADDRESS(II different	ory	12. REPORT DATE Sept. 1983 13. NUMBER OF PAGES 34 15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Submitted for publication in Experimental Mechanics Journal

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Fatigue Cracks

Multiple Fatigue Cracks

Thick-Wall Cylinders

Crack Shape

Autofrettage

Strain Measurements

Lame' Strain

Ultrasonics

20. ABSTRACT (Continue on reverse side if recoverary and identity by block number)

Thick-walled cylinders containing more than one internal crack are compared with one containing a single crack. Their crack growth and strain behavior show that one of the cracks becomes dominant and controls the failure. Monitoring the circumferential strain over the dominant crack gives an indication of when failure is imminent.

DD 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

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ONTRACT OR GRANT NUMBER(e)
PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
MS NO.6111.02.H600.011
N NO 14725D5 41414
N NO.1A325B541A1A
Sept. 1983
NUMBER OF PAGES 27
SECURITY CLASS. (of this report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

7.70 be presented at American Society of Lubrication Engineers Meeting, Chicago, 7-10 May 1984, and to be published in the ASLE Transactions.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Melt-lubrication

Lubrication

Projectile Lubrication

Rotating Bands

20. ABSTRACT (Cantinue on reverse side if necessary and identify by block number)

Despite the long-time acceptance of melt-lubrication of rotating bands by the Army Scientific community, all of the evidence supporting this conclusion has not been collected and, indeed, some has never been published. The melt-lubrication of rotating bands is very important because then sliding is lubricated and friction and wear is determined only by the characteristics of the molten film and the amount of melting at the sliding interface. Melt
(CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

lubrication results in much less resistance and much less severe wear than would otherwise be the case. Friction, wear and metallographic evidence from examination of recovered projectiles and fired cannon tubes show the melt-lubrication of projectiles sliding on a gun bore. This melt-lubrication is caused by the production of a thin surface film of molten rotating band material. Such a molten surface layer can also be produced on the surface of materials other than copper alloys contacting the bore at high bearing loads.

REPORT DOCUMENTATION	READ INSTRUCTIONS BEFORE COMPLETING FORM			
1. REPORT NUMBER ARLCB-TR-83032	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER		
4. TITLE (and Subtitle) ELECTRICAL TRANSPORT IN LOW RESIST: AMORPHOUS ALLOYS	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER			
7. AUTHOR(*) L. V. Meisel and P. J. Cote	8. CONTRACT OR GRANT NUMBER(*)			
9. PERFORMING ORGANIZATION NAME AND ADDRES US Army Armament Research & Develor Benet Weapons Laboratory, DRSMC-LO Watervliet, NY 12189	pment Center	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO.6111.02.H600.011 PRON NO.1A325B541A1A		
US Army Armament Research & Develor Large Caliber Weapon Systems Labor Dover, NJ 07801	Sept. 1983 13. NUMBER OF PAGES 33			
14. MONITORING AGENCY NAME & ADDRESS(# dittere	ent from Controlling Office)	1S. SECURITY CLASS. (of this report) Unclassified 1Se. DECLASSIFICATION/DOWNGRADING SCHEDULE		

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- 17. DISTRIBUTION STATEMENT (of the abetract entered in Block 20, if different from Report)
- 18. SUPPLEMENTARY NOTES Presented at the meeting of American Physical Society, March 1983. Submitted to the Journal, Physical Review.
- 19. KEY WORDS (Continue on reverse elds if necessary and identify by block number)

Electrical Transport Amorphous Alloys Diffraction Model Saturation Effects

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Diffraction model calculations incorporating appropriate scattering matrix elements and phonon ineffectiveness effects (saturation effects) yield results which are consistent with the observed temperature dependence of the electrical resistivity in low resistivity ($\rho < 100~\mu\Omega \text{cm}$) amorphous alloys. In particular, remarkably good quantitative agreement with available detailed resistivity measurements in a-MgZn alloys has been obtained by these methods. The results (CONT'D ON REVERSE)

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20.	ABSTRACT	(CONT'D)		
fur	ther indica	ate that saturation	n effects, which dominate	the temperature
dep	endence of	the high resistiv	ity amorphous metals, are	important even for
res	istivities	as low as 50 $\mu\Omega$ cm	•	
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REPORT DOCUMENTATION	PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER	3. RECIPIENT'S CATALOG NUMBER		
ARLCB-TR-83033			
4. TITLE (and Subtitle) CHARACTERIZATION OF CRYSTALLOGRAPHI AND INTERNAL STRESS OF CHROMIUM COA UNDER CURRENT INTERRUPTIONS	Final 6. PERFORMING ORG. REPORT NUMBER		
7. AUTHOR(s) G. P. Capsimalis and E. S. Chen		8. CONTRACT OR GRANT NUMBER(*)	
9. PERFORMING ORGANIZATION NAME AND ADDRES US Army Armament Research & Develor Benet Weapons Laboratory, DRSMC-LO Watervliet, NY 12189	pment Center	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.6111.01.91A0.0 Pron:1A1281501A1A	
11. controlling office name and address US Army Armament Research & Develor Large Caliber Weapon Systems Labora Dover, NJ 07801 14. MONITORING AGENCY NAME & ADDRESS(11 d) (116-14)	atory	12. REPORT DATE Sept. 1983 13. NUMBER OF PAGES 15 15. SECURITY CLASS. (of this report)	

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES Presented at the Tri-service Symposium on Gun Tube Wear and Erosion, 25-28 Oct. 1982, Dover, New Jersey and published in the Proceedings.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Chromium Plating

Crystal Structure

Current Interruptions

Texture

Microstructure

Stress

Hardness

Microcrack Morphology

20. ABSTRACT (Continue on reverse state if necessary and identify by block number)

The effect of interrupted current (IC) plating on the visual crack morphology, crystallography, and residual stresses of electrodeposited chromium has been investigated. Varying the process parameters such as the on/off plating cycle and current density resulted in changing the crystallographic fiber texture of the deposit from the conventional <111> orientation to a combination of <211>, <111>, and a small fraction of randomly oriented crystallites. Under (CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

these plating conditions, it was also found that (1) lower amounts of chromium hydride (CrH_X) occur in the deposit, (2) a large decrease in the microcrack density of the deposit occurs, and (3) the deposits tend to become compressively stressed.

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
I. REPORT NUMBER 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83034	
4. TITLE (and Subtitle) SAMPLE PREPARATION AND EVALUATION OF STEEL SPECIMENS FOR INCLUSION RETENTION AND SUBSEQUENT	5. TYPE OF REPORT & PERIOD COVERED Final
AUTOMATED ASSESSMENT	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) Theresa V. Brassard	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
US Army Armament Research & Development Center	October 1983
Large Caliber Weapon Systems Laboratory Dover, NJ 07801	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)	15. SECURITY CLASS. (of this report)
	UNCLASSIFIED
	15. DECLASSIFICATION/DOWNGRADING SCHEDULE

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17. DISTRIBUTION STATEMENT (of the abetrect entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This report has been approved and accepted by ASTM as a standard practice for preparing and evaluating specimens for automatic inclusion assessment of steel. It is published in the Annual Book of ASTM Standards, Part 11.

19. KEY WORDS (Continue on reveree elde if necessary and identify by block number)

Standard Practice

Metallographic Preparation

Steel

Inclusions

Interference Microscopy

20. ABSTRACT (Continue on reverse side if recessery and identify by block number)

A recommended practice for preparation and evaluation of steel specimens for automatic inclusion assessment was developed. The polishing procedure involved the use of diamond abrasives on rotating paper laps. This technique preserved the true morphology of the non-metallic inclusions. Evaluation of a properly prepared sample was accomplished using the sensitive tint condition of Differential Interference Contrast Microscopy.

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1. REPORT NUMBER 2. GOVT ACCESSION NO.		3. RECIPIENT'S CATALOG NUMBER			
ARLCB-MR-83035					
4. TITLE (and Subtitle) MICROSTRUCTURAL ANALYSIS OF A RAPIDI	5. TYPE OF REPORT & PERIOD COVERED				
FIVE-INCH NAVY GUN TUBE	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Final			
		6. PERFORMING ORG. REPORT NUMBER			
7. AUTHOR(*) T. Brassard and J. F. Throop	8. CONTRACT OR GRANT NUMBER(#)				
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Develo	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS				
Benet Weapons Laboratory, DRSMC-LCB-	AMCMS No. 612105.H840011				
Watervliet, NY 12189	PRON No. 1A1236951A1A				
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE			
US Army Armament Research and Develo		October 1983			
Large Caliber Weapon Systems Laborat Dover, NJ 07801	.ory	13. NUMBER OF PAGES			
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14. MONITORING AGENCY NAME & ADDRESS(If differen	I from Controlling Office)	is. Seconi i Censs. (or the seport)			
		UNCLASSIFIED			
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17. DISTRIBUTION STATEMENT (of the ebetraci enlered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary end identity by block number)

Metallography

White Layer

Gun Steel

Navy Tube

Erosion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A metallographic analysis was performed on various sections along the bore surface of a rapidly fired Navy cannon. This rapid firing program produced the most severe thermal environment ever achieved in a medium caliber gun, and thus exceeded the barrel thermal design parameters.

An attempt was made to characterize the heat affected zone or so-called "white layer" which formed on the bore surface of the tube. Identification of the (CONT'D ON REVERSE)

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20. ABSTRACT (CONT'D)

microstructures comprising the layers of this thermally altered zone was made by microstructural appearances and resulting microhardness data obtained from the individual layers.

The heat affected zone or "white layer" produced along the bore of the fired Navy tube proved to be similar to that found on the bore of the fired 105 mm M68 cannons. Thickness of these layers varied along the surface of the bore. It was noted that the thickest layers were found on land corners. Chromium plating protected the surface from the excessive heat and the resulting formation of "white layer". However, once cracking began to occur in the chromium plate, the effect of elevated temperature produced during firing was evidenced in the change of microstructure and microhardness in the area directly beneath the crack.

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1. REPORT NUMBER	EPORT NUMBER 2. GOVT ACCESSION NO.					
ARLCB-MR-83036						
4. TITLE (and Subtitie)		5. TYPE OF REPORT & PERIOD COVERED				
COLD ROTARY FORGING OF A THIN-WALLI	Final					
		6. PERFORMING ORG. REPORT NUMBER				
7. AUTHOR(*)		8. CONTRACT OR GRANT NUMBER(*)				
Boaz Avitzur						
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS				
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	UNCLASSIFIED					
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16. DISTRIBUTION STATEMENT (of this Report)						
Approved for public release; distribution unlimited.						
17. DISTRIBUTION STATEMENT (of the abetract entered in Block 20, if different from Report)						
16. SUPPLEMENTARY NOTES						
19. KEY WORDS (Continue on reverse side if necessary and	d identify by block number)					
Artillery	Forging (Radial)	(Rotary)				
	Sum Barrels	(===,)				
Forge (Presses)	steel					
20. ABSTRACT (Continue on reverse side if recessary and	Lidentify by block number)					
In Technical Report WVT-TR-75054 on cold rotary forging of rifling into a thin-wall gun tube, it was stated that the yield strength of the forged material increased in the longitudinal direction, while a recoverable loss was observed in the tangential (hoop) direction.						

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A recently obtained metallographic study of the same material suggests a potential improvement in fatigue life and/or fracture toughness of the

material, attained in that earlier work but overlooked at the time.

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER		
ARLCB-TR-83037				
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED		
CONCEPT STUDY OF LIGHTWEIGHT LARGE WEAPONS FOR MOBILE PROTECTED GUN SY	FINAL			
THE GIVE TON MODILE THOTEGIES GON OF	6. PERFORMING ORG. REPORT NUMBER			
7. AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(#)		
R. H. COLE				
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS			
US Army Armament Research and Devel	-	AMCMS No: 643635.166.0011		
Benet Weapons Laboratory, DRSMC-LCB	DA Proj.:			
Watervliet, N.Y. 12189		PRON No.: 1A225E731A1A		
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE			
US Army Armament Research and Devel	-	OCTOBER 1983		
Large Caliber Weapon System Laborat	ory	13. NUMBER OF PAGES		
Dover, New Jersey 07801		66		
14. MONITORING AGENCY NAME & ADDRESS(if differen	t from Controlling Office)	15. SECURITY CLASS. (of thie report)		
		UNCLASSIFIED		
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE			
16. DISTRIBUTION STATEMENT (of this Report)				
Dist	ribution limited	to US Government Agencies		
because of Test and Evaluation, Oct	ober 1983. Othe	r requests for this document		
must be referred to Commander, US A ATTN: DRSMC-LCB-DS, Watervliet, N.		and Development Center,		

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

LIGHTWEIGHT MOBILE GUN SYSTEM AUTOLOADER CONCEPTS LIGHTWEIGHT CANNON GUN MOUNT LONG RECOIL SYSTEM

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents the work done on a program to develop lightweight large caliber autoloaded weapon concepts for use on a Mobile Protected Gun System (MPGS) 15 ton vehicle.

Lightweight gun tubes, breeches and recoil mechanism/mount configurations were developed with the principle of long recoil travel used to minimize recoil forces; 105MM and 120MM weapons were included in the study. Concepts for automatic loading of the weapons were developed with the weapon systems placed within a specified MPGS envelope.

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ARLCB-TR-83038 4. TITLE (and Subtitio)	5. TYPE OF REPORT & PERIOD COVERED			
ELASTIC PROPERTIES OF URANIUM78 TITANIUM AS A FUNCTION OF PRESSURE TO 1.6 GPa	Final			
	6. PERFORMING ORG. REPORT NUMBER			
7. AUTHOR(*) J. Frankel and D. Dandekar* *See Reverse	8. CONTRACT OR GRANT NUMBER(*)			
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 PRON No. 1A1283121A1A			
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE			
US Army Armament Research & Development Center	October 1983			
Large Caliber Weapon Systems Laboratory	13. NUMBER OF PAGES			
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at AIRAPT Conference, Uppsala, Sweden, 15-22 August 1981. Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Uranium

Ultrasonic Velocities

Pressure

Elastic Properties

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The transit time for passage of longitudinal and shear ultrasonic waves through polycrystalline depleted uranium - .78 weight percent titanium (Ti) alloy was determined as a function of pressure in a hydrostatic medium. Specimens of two thicknesses were used in order to eliminate bond-transducer effects from transit time determinations. The longitudinal velocity vL increases 3.5 percent from one atmosphere to a value of 3.48 km/sec at 1.6 GPa; the shear (CONT'D ON REVERSE)

7. AUTHORS

D. Dandekar*
U.S. Army Materials and Mechanics Research Center
Watertown, MA 02172

20. ABSTRACT (CONT'D)

velocity v_g increases 5 percent to 2.08 km/sec; the adiabatic bulk modulus B^s increases 8.1 percent to a value of 120 GPa and the shear modulus μ , 9.4 percent to 81 GPa over the same pressure range.

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1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER		
ARLCB -MR-83039				
4. TITLE (and Subtitie) DETERMINATION OF THE HEAT TREATMENT CHARACTER-		5. TYPE OF REPORT & PERIOD COVERED		
ISTICS OF VARIOUS GUN STEELS BY COM THERMOMAGNETIC AND DIFFERENTIAL THE		Final		
THERMOMAGNETIC AND DIFFERENTIAL THE	iden initiatoro	6. PERFORMING ORG. REPORT NUMBER		
7. AUTHOR(*) P. J. Cote		8. CONTRACT OR GRANT NUMBER(a)		
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS		
US Army Armament Research & Develop Benet Weapons Laboratory, DRSMC-LCB		AMCMS No.6111.02.H600.011		
Watervliet, NY 12189		PRON NO.1A325B541A1A		
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Develop	ment Center	12. REPORT DATE		
Large Caliber Weapon Systems Labora		November 1983		
Dover, NJ 07801	,	11		
14. MONITORING AGENCY NAME & ADDRESS(II differen	t from Controlling Office)	15. SECURITY CLASS. (of thie report)		
		Unclassified		
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report)				
Distribution limited to US Government Agencies because of Test and Evaluation, October 1983. Other requests for this document must be referred to Commander, US Armament Research and Development Center, ATTN: DRSMC-LCB-RP, Watervliet, NY 12189.				
17. DISTRIBUTION STATEMENT (of the abetract entered	in Block 20, if different fro	m Report)		
18. SUPPLEMENTARY NOTES				
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)				
Magnetic Analysis				
Differential Thermal Analysis Thermogravimetric Analysis				
Gun Steel				
Quench Transformations				
20. ABSTRACT (Continue on reverse side if necessary and identity by block number) A study was conducted, in collaboration with the Engineering Support Branch,				
with the initial goal of determining the suitability of applying a magnetic				
probe to gun tubes to monitor phase transitions during the heat treat process.				
Measurements were made in the laboratory using a DTA-TGA apparatus which was				
modified so that a magnetic force could be applied to a sample in order to				
monitor its magnetic state during the entire heating and cooling cycle. The (CONT'D ON REVERSE)				

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I. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
ARLCB-TR-83040		
4. TITLE (and Subtitle) FATIGUE LIFE ANALYSIS AND TENSILE OVERLOAD EFFECTS WITH HIGH STRENGTH STEEL NOTCHED SPECIMENS		5. TYPE OF REPORT & PERIOD COVERED
		Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(*)
J. H. Underwood		
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		PRON No. 1A325D021A1A
US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		November 1983
		13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)		15. SECURITY CLASS, (of this report)
		UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at IX AIRAPT International High Pressure Conference, Albany, NY 27-28 July 1983.

Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse eids if necessary and identify by block number)

Fatigue Life

High Strength Steel

Residual Stress

Notched Bend Test

Stress Concentration

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Fatigue crack growth results are presented for a series of tests of high strength steel notched-bending specimens. Eight values of stress concentration factor from 1.5 to 4 were represented in the tests, as well as six forging procedures with yield strengths from about 1000 to 1200 MPa. The cyclic lives of the specimens, ranging from about 2000 to 100,000 cycles, were analyzed, using fatigue stress range calculated from stress concentration factor and from (CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

a fracture mechanics method. A statistical comparison of the two methods was performed. Photoelastic and finite element methods were used to obtain some of the notch root stresses.

The effects of a single prior tensile overload on fatigue life were considered for many of the tests. There appeared to be a critical ratio (about unity) of cyclic stress range at the notch root relative to yield strength, below which a tensile overload extended fatigue life and above which a tensile overload shortened life.

The effects of prior thermal overload on fatigue life were also investigated in five tests of two specimen geometries. Rapid cooling of the outer diameter of a hollow disk segment of a cylinder extended the fatigue life in subsequent cyclic bending testing of the segment.

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A. TITLE (and Subtitio)		
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PREDICTION OF RESIDUAL STRESSES IN AN AUTOFRETTAGED THICK-WALLED CYLINDER		Final
		6. PERFORMING ORG. REPORT NUMBER
		V. PERFORMING ONG. REPORT NUMBER
7. AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(*)
Peter C. T. Chen		
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL		AMCMS NO. 6111.02.H600.011
Watervliet, NY 12189		PRON NO. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
US Army Armament Research & Development Center		November 1983
Large Caliber Weapon Systems Laboratory		13. NUMBER OF PAGES
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18. SUPPLEMENTARY NOTES

Presented at the IX AIRAPT Conference on High Pressure in Science and Technology, State University of New York at Albany, 24-29 July 1983.

19. KEY WORDS (Continue on reverse eide if necessary and identify by block number)

Autofrettaged Tube Residual Stress Bauschinger Effect Strain-Hardening Reverse Yielding

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

Most of the earlier results for residual stresses are based on the assumption of elastic unloading. In this report, the prediction of residual stresses for the case of reverse yielding including the combined Bauschinger and hardening effect will be reported for an autofrettaged thick-walled cylinder. The Bauschinger effect factor is varying as a function of overstrain. The strain-hardening effect is considered with different parameters used for loading and unloading process. The new results indicate that the influence of the combined Bauschinger and hardening effect on residual stress distribution is significant.

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ARLCB-TR-83042			
4. TITLE (and Subtitle)		S. TYPE OF REPORT & PERIOD COVERED	
MEASUREMENT OF THE EXTENT OF AUTOFRETTAGE IN		Final	
TUBE SECTIONS	TUBE SECTIONS		
		6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(e)		8. CONTRACT OR GRANT NUMBER(*)	
Bruce B. Brown		3	
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9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
US Army Armament Research & Develo	pment Center	AMCMS No. 2080.15.6000.0	
Benet Weapons Laboratory, DRSMC-LC		PRON No. 1A1221B81A1A	
Watervliet, NY 12189			
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE December 1983	
US Army Armament Research & Develo Large Caliber Weapon Systems Labor		13. NUMBER OF PAGES	
Dover, NJ 07801		13	
14. MONITORING AGENCY NAME & ADDRESS(II different	t from Controlling Office)	1S. SECURITY CLASS. (of thie report)	
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		154. DECLASSIFICATION/DOWNGRADING SCHEDULE	
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17. DISTRIBUTION STATEMENT (of the ebetrect entered	in Block 20, if different from	m Report)	
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse elde if necessary and identify by block number)			
Autofrettage			
Residual Stress Fatigue			
Tube			
Measurement			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)			
The fatigue behavior of a pressurized tube is directly dependent on the			
residual stresses created by the autofrettage process. A method is presented			
that unites a convenient measurement technique with a fundamental relationship to yield the degree of autofrettage present in the tube expressed as percent			
overstrain. This provides a critical datum in the analysis of fatigue data.			

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J. H. Underwood and M. A. Scavullo	8. CONTRACT OR GRANT NUMBER(#)
PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
US Army Armament Research & Development Cen Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189	AMCMS No. 6126.03.H180.0 PRON No. 1A325B461A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Cen	ter December 1983
Large Caliber Weapon Systems Laboratory Dover, NJ 07801	13. NUMBER OF PAGES 29
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18. SUPPLEMENTARY NOTES

Presented at Sixteenth National Symposium on Fracture Mechanics, ASTM, Columbus, Ohio, 15-18 August 1983.
Published in proceedings of the symposium.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Uranium Alloy Tungsten Alloy Brittle Fracture Nondestructive Inspection

Stress Analysis

20. ABSTRACT (Continue on reverse side if necessary and identity by block number)

A failure of a prototype long rod penetrator is described, including the stress and fracture analyses performed, the materials and service simulation testing performed, and the fracture toughness and nondestructive inspection requirements which were implemented.

Results of a subsequent study are described, which involve the producibility of the long rod penetrator, particularly in relation to the complex fracture toughness testing methods which are required for use with this component.

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A. TITLE (and Subtitio) MAGNETIC BEHAVIOR OF PRESSURE QUENCHED CADMIUM SULFIDE CONTAINING CHLORINE	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
P. J. Cote, C. G. Homan, W. C. Moffatt, S. Block, G. P. Piermarini, and R. K. MacCrone (SEE REVERSE SIDE)	8. CONTRACT OR GRANT NUMBER(*) AFOSR Contract No. 79-0126 ONR Contract No. N00014-80-C-0828
D. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A
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18. SUPPLEMENTARY NOTES

Presented at IX AIRAPT International High Pressure Conference, Albany, NY, 26 July 1983. Submitted to the journal, Physical Review.

19. KEY WORDS (Continue on reverse side if necessary and identity by block number)

 $CdS_{2x}Cl_{2-x}$

Pressure Quenched

Diamagnetism

Paramagnetism

Superconductivity

20. ABSTRACT (Continue on reverse state if necessary and identity by block number)
Pressure quenched cadmium sulfide (CdS) containing chlorine (Cl) has been shown previously to exhibit both very large diamagnetism and paramagnetism. The diamagnetism observed at 77K approached Meissner proportion and suggested superconducting like behavior in this material. The effect is known to depend sensitively on the Cl content of the starting material. This report describes the results of a survey of the magnetic behavior of pressure quenched samples (CONT'D ON REVERSE)

7. AUTHOR(S) (CONT'D)

S. Block and G. P. Piermarini National Bureau of Standards Washington, D.C.

R. K. MacCrone Rensselaer Polytechnic Institute Troy, NY

20. ABSTRACT (CONT'D)

prepared from CdS systematically doped with increasing amounts of Cl.

The Cl doped material was prepared in a variety of ways: from mixtures of CdS and CdCl₂, by precipitation from aqueous solution, and by acid doping. The differently doped starting materials were analyzed for Cl and other impurities before being pressure quenched. The magnetic susceptibilities were subsequently measured.

The results of the survey indicate that the concentration of Cl required to produce specimens with anomalously large magnetism is 0.75 ± 0.10 weight percent. The technique for the preparation of such material is described.

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4. TITLE (end Subtitle) MECHANICAL PROPERTIES OF SILICONE RUBBER IN A CLOSED VOLUME		s. Type of REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*) G. P. O'Hara		8. CONTRACT OR GRANT NUMBER(*)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Develop Benet Weapons Laboratory, DRSMC-LCB- Watervliet, NY 12189	ment Center	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 2080.15.6000.0 PRON No. 1A1221B81A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Develop		12. REPORT DATE December 1983
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse eide if necessary and identify by block number)

Rubber

Experiment

Modulus

Elastomer

Silicone

Pressure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report covers an experiment to measure the mechanical properties of four samples of RTV silicone rubber. The test was conducted under conditions of small strains and an elevated hydrostatic pressure component of stress (0 -4000 psi). The results gave a Young's modulus in the range of 13,000 to 21,000 and a Poisson's ratio range of 0.48 to 0.49. The Young's modulus values were much higher than the usual tensile values; however, a calculation of bulk modulus gave values which were within the accepted range.

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1. TITLE (and Subtitie)		S. TYPE OF REPORT & PERIOD COVERED
		Final Technical Report
MANUFACTURE OF SPLIT RING BREECH SEALS		Jan 79 - Sep 81
		5. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(*)		8. CONTRACT OR GRANT NUMBER(*)
Rocco S. DeMeo		
PERFORMING ORGANIZATION NAME AND		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T project to the U.S. Army Armament Materiel Readiness Command in September 1981.

19. KEY WORDS (Continue on reveree elds if necessary and identify by block number)

Split Ring Breech Seal Hydraulic Kinking Machine Splitting the Ring Polishing Split Surfaces

20. ABSTRACT (Continue on reverse side if recovery and identity by block number)

An engineering survey relative to the problems associated with split ring manufacturing was undertaken. The results of this effort are as follows:

1. Kinking: A hydraulically operated kinking machine has been built in-house. Initial testing is very promising. Modification and refinements to this unit are continuing.

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(CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

- 2. Splitting the Ring: The feasibility of splitting the ring using an electrical discharge machine "EDM" was investigated. A service contract for EDM cutting employing a traveling wire electrode was awarded. This method proved unsatisfactory for production application. A specification for an automated abrasive saw has been prepared. This machine will have power clamping, adjustable cutting feeds, constant surface feet per minute "SFM" wheel control, wheel guides for stability and self-contained coolant system.
- 3. Polishing Split Surface: The engineering study failed in locating an adaptable state of the art polishing machine that would meet the rigid requirements of our components. In order to improve on our present method of polishing, an in-house effort has been undertaken. Two wet belt sanders have been purchased and the modification for our application has begun.

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I. REPORT NUMBER 2. GOVT ACCESSION NO. ARLCB-TR-83047	3. RECIPIENT'S CATALOG NUMBER	
A. TITLE (end Subtitie) FINITE ELEMENT RESULTS OF PRESSURIZED THICK TUBES BASED ON TWO ELASTIC-PLASTIC MATERIAL MODELS	5. Type of Report & Period Covered Final 6. Performing org. Report Number	
P. C. T. Chen and G. P. O'Hara	8. CONTRACT OR GRANT NUMBER(*)	
PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A	
U. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE December 1983 13. NUMBER OF PAGES 20	
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18. SUPPLEMENTARY NOTES

Presented at the First Army Conference on Applied Mathematics and Computing at George Washington University, Washington, DC, 9-11 May 1983.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Thick Tube

Isotropic Hardening

Elastic-Plastic

Kinematic Hardening

Finite Element Method

ADINA Code

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The loading and unloading problems in thick tubes subjected to uniform internal pressure have been analyzed with the ADINA finite element code. The elastic-plastic materials are modeled by two strain-hardening rules - isotropic and kinematic. The von Mises yield condition, the associated flow theory, and a multi-linear stress-strain curve are used in both material models. The numerical results of the stresses and displacements for thick tubes with different wall ratios are obtained as functions of loading history. A comparison of numerical results based on two material models is made.

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4. TITLE (and Subtitle) EXPLICIT FORMULAS FOR CD PIECEWISE HERMITE		5. TYPE OF REPORT & PERIOD COVERED	
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		6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(a)		8. CONTRACT OR GRANT NUMBER(*)	
Royce W. Soanes, Jr.			
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK	
US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
		AMCMS No. 6111.02.H600.011	
Watervliet, NY 12189		PRON No. 1A325B541A1A	
II. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE	
US Army Armament Research & Develop		December 1983	
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14. MONITORING AGENCY NAME & AODRESS(If different from Controlling Office)		15. SECURITY CLASS. (of this report)	
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18. SUPPLEMENTARY NOTES

Presented at First Army Conference on Applied Mathematics and Computing, George Washington University, Washington, D.C., 9-11 May 1983. Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hermite

Finite Support

Piecewise Defined

Finite Elements

Basis Functions

Splines

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Completely factored forms of the piecewise Hermite basis functions are derived. All necessary coefficients for any level of smoothness are shown to reside conveniently in Pascal's triangle.

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